Forward Λ_b production in pp collisions at LHC

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As is well known, there are successful phenomenological approaches for describing the soft hadron-nucleon, hadron-nucleus and nucleus-nucleus interactions at high energies based on the Regge theory and the $1/N$ expansion in QCD, for example the quark-gluon string model (QGSM) [1] and the dual parton model (DPM) [2]. In this paper we present the results on the beauty baryon production, in particular Λ_b, in pp collisions at LHC energies and small p_t within the QGSM to find the information on the Regge trajectories of the bottom ($b\bar{b}$) mesons and the fragmentation functions (FF) of all the quarks and diquarks to this baryon. Actually, these results are the predictions for the LHC experiments.

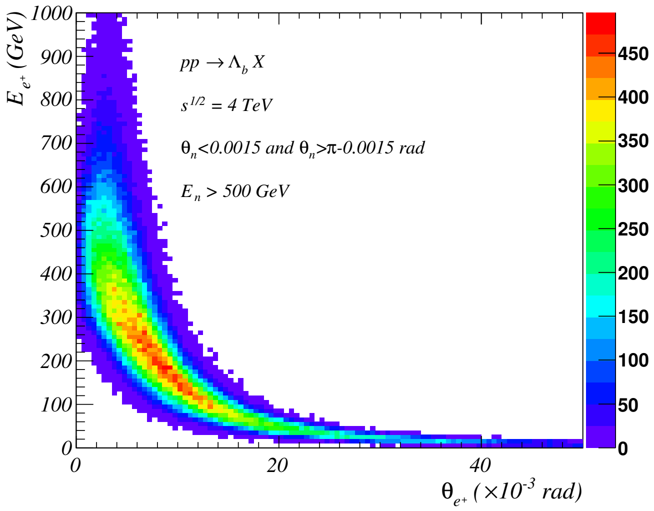

Figure 1: The distribution over θ_{e^+} and E_{e^+} in the inclusive process $pp \to \Lambda_b X \to J/\psi\, \Lambda^0 X \to e^+e^- n\, \pi^0 X$ at $\sqrt{s} = 4\,\text{GeV}$. The rate of the events is about 4.6 percent (13.8 nb).

The detailed calculations and the predictions on these reactions are presented in [3, 4], where it is shown that all the observables are very sensitive to the value of intercept $\alpha_\Upsilon(0)$ of the $\Upsilon(b\bar{b})$ Regge trajectory. The upper limit of our results is reached at $\alpha_\Upsilon(0) = 0$, when this Regge trajectory as a function of the transfer t is nonlinear. Using the hadron detector at the CMS and the TOTEM one could register the decay $\Lambda_b^0 \to J/\psi\, \Lambda^0 \to \mu^+\mu^-\pi^-p$ by detecting two muons and one proton emitted forward. However, the acceptance of the muon detector is $10° \leq \theta_\mu \leq 170°$ [5], where, according to our calculations, the fraction of these events is too low.

On the other hand, the electromagnetic calorimeter at the CMS is able to measure the dielectron pairs e^+e^- in the acceptance about $1^\circ \leq \theta_{e(e^+)} \leq 179^\circ$ [6]. Fig. 1 illustrates that the electrons and positrons produced from the J/ψ decay are emitted at very small scattering angles, mainly at $\theta_e < 16$ mrad. The rate of these events, when the neutrons are emitted at $\theta_n < 1.5$ mrad and $E_n > 500$ GeV, is about 4.6 percent (13.8 nb). In Fig. 2 the two-dimensional distribution over E_p and θ_p for the reaction $pp \to \Lambda_b X \to J/\psi\,\Lambda^0 X \to e^+e^- p\,\pi^- X$ is presented. The rate of these events is about 0.74 percent (2.22 nb). This could be reliable using the TOTEM together with the CMS [7].

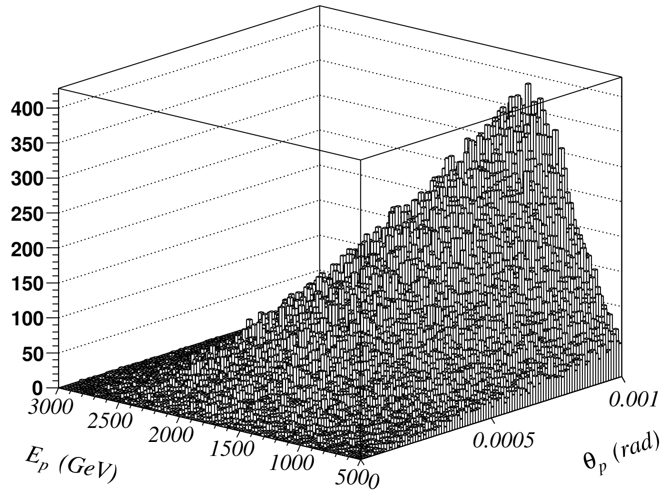

Figure 2: The two-dimensional distribution over θ_p and E_p in the inclusive process $pp \to \Lambda_b X \to J/\psi\,\Lambda^0 X \to e^+e^- p\,\pi^- X$ at $\sqrt{s} = 10$ TeV at $\alpha_\Upsilon(0) = 0$, when $E_p \geq 500$ GeV and $\theta_p \leq 1$ mrad. The rate of these events is about 0.74 percent (2.22 nb).

The ATLAS is able also to detect e^+e^- by the electromagnetic calorimeter in the interval $1^\circ \leq \theta_{e(e^+)} \leq 179^\circ$ [5] and the neutrons emitted forward at the angles $\theta_n \leq 0.1$ mrad [8]. In Fig. 3 we present the prediction for the reaction $pp \to \Lambda_b X \to J/\psi\,\Lambda^0 X \to e^+e^- n\,\pi^0 X$, that could be reliable at the ATLAS experiment. The rate of these events is about 0.015 percent (45 pb).

The TOTEM [9] together with the CMS might be able to measure the channel $\Lambda_b \to J/\psi\,\Lambda^0 \to e^+e^-\pi^- p$ (the integrated cross-section is about 0.2–0.3 μb at $\alpha_\Upsilon(0) = 0$ and smaller at $\alpha_\Upsilon(0) = -8$). The T2 and T1 tracking stations of the TOTEM apparatus have their angular acceptance in the intervals 3 mrad $< \theta <$ 10 mrad (corresponding to $6.5 > \eta > 5.3$) and 18 mrad $< \theta <$ 90 mrad (corresponding to $4.7 > \eta > 3.1$) respectively, and could thus detect 42% of the muons from the J/ψ decay. In the same angular intervals, 36% of the π^- and 35% of the protons from the Λ^0 decay are expected. According to a very preliminary estimate [7], protons with energies above 3.4 TeV emitted at angles smaller than 0.6 mrad could be detected in the Roman Pot station at 147 m from IP5 [9, 7]. In the latter case, the reconstruction of the proton kinematics may be possible, whereas the trackers T1 and T2 do not provide any momentum or energy information. Future detailed studies are to establish the full event topologies with all correlations between the observables in order to assess whether the signal events can be identified and separated from backgrounds. These investigations should also

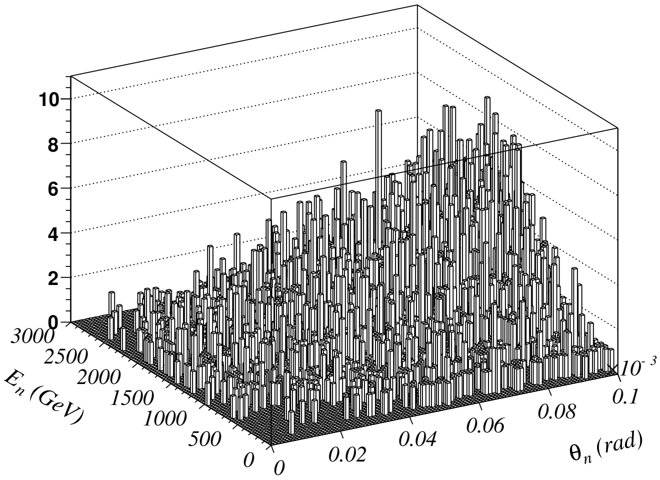

Figure 3: The two-dimensional distribution over θ_p and E_p in the inclusive process $pp \to \Lambda_b X \to J/\psi\, \Lambda^0 X \to e^+e^- n\, \pi^0 X$ at $\sqrt{s} = 10\,\mathrm{TeV}$ at $\alpha_\Upsilon(0) = 0$, when $\theta_p \leq 0.1\,\mathrm{mrad}$. The rate of these events is about 0.015 percent (45 pb).

include the CMS calorimeters HF and CASTOR which cover the same angular ranges as T1 and T2 respectively [7].

Acknowledgments

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